WHAT IS CLAIMED IS:

1. A refueling drogue, comprising:

a rotatable mass; wherein

the rotatable mass is adapted to effectively stabilize the refueling drogue via a gyroscopic effect of the rotating mass on the refueling drogue when the refueling drogue is placed in an airstream.

2. The refueling drogue according to claim 1, wherein the rotatable mass is adapted to effectively stabilize the refueling drogue via a gyroscopic effect of the rotating mass on the refueling drogue when the refueling drogue is placed in an airstream having a relative velocity to the refueling drogue of more than about 80 KEAS.

3. The refueling drogue of claim 1, wherein the rotating mass includes a refueling drogue basket.

4. The refueling drogue of claim 1, wherein the rotating mass includes a refueling drogue body or a portion of the refueling drogue body.

5. The refueling drogue of claim 4, wherein the refueling drogue body is connected to at least one of a refueling hose and a component that is connected to a refueling hose by a coupler adapted to permit the refueling drogue body to rotate relative to the refueling hose.

6. The refueling drogue of claim 1, wherein the refueling drogue includes a refueling drogue basket, and wherein the rotating mass is adapted to rotate relative to the refueling drogue basket.

7. The refueling drogue of claim 1, wherein the refueling drogue includes a refueling drogue body, and wherein the rotating mass is adapted to rotate relative to the refueling drogue body.

8. The refueling drogue of claim 2, further comprising a refueling hose.

9. The refueling drogue of claim 2, further comprising a refueling hose in fluid communication with the refueling drogue, wherein the refueling hose interior diameter is about 2.2 inches to about 3.0 inches in diameter.

10. The refueling drogue of claim 2, wherein the refueling drogue extends from an airborne refueling aircraft and is adapted to transfer aviation fuel from the airborne refueling aircraft to a receiver aircraft.

11. The refueling drogue of claim 2, wherein the refueling drogue is adapted to physically connect one airborne aircraft to another airborne aircraft.

12. The refueling drogue of claim 2, wherein the refueling drogue is adapted to physically connect with a refueling probe of a receiver aircraft, wherein the rotating mass has an axis of rotation, wherein the axis of rotation is adapted to be substantially coaxial with an axis of symmetry of the refueling drogue, and wherein the axis of symmetry of the refueling drogue passes through the center of gravity of the refueling drogue.

13. The refueling drogue of claim 1, wherein effective stabilization is obtained without the use of an active control system.

14. The refueling drogue of claim 1, wherein effective stabilization is obtained passively.

15. The refueling drogue of claim 1, wherein the drogue is adapted to harness an air stream flowing past the refueling drogue that results from a forward velocity of the refueling drogue through the atmosphere to rotate the rotatable mass to produce the gyroscopic effect.

16. The refueling drogue of claim 1, wherein the refueling drogue comprises a plurality of rotatable surfaces that, when exposed to an air stream flowing past the refueling drogue that results from a forward velocity of the refueling drogue through the atmosphere, are adapted to rotate the rotatable mass due to aerodynamic forces on the surfaces to produce the gyroscopic effect.

17. The refueling drogue of claim 16, wherein the surfaces are outside of the refueling drogue.

18. The refueling drogue of claim 16, wherein the surfaces are inside the refueling drogue.

19. The refueling drogue of claim 1, wherein the refueling drogue comprises a plurality of surfaces that, when exposed to an airstream coming from a compressed air supply, are adapted to rotate the rotatable mass due to aerodynamic forces on the surfaces to produce the gyroscopic effect.

20. The refueling drogue of claim 1, wherein the rotating mass is connected to an air turbine, and wherein the air turbine is adapted to rotate the rotatable mass when exposed to the air stream when the air stream has a relative velocity to the refueling drogue in excess of about 50 KEAS to produce the gyroscopic effect.

21. The refueling drogue of claim 20, wherein the air turbine is located on the outside of the refueling drogue.

22. The refueling drogue of claim 20, wherein the air turbine extends radially from the refueling drogue.

23. The refueling drogue of claim 20, wherein the air turbine is located on the inside of the refueling drogue.

24. The refueling drogue of claim 23, wherein the air turbine is also located on the outside of the refueling drogue.

25. The refueling drogue of claim 20, wherein the air turbine is adapted to extend outward away from the refueling drogue and retract inward towards the refueling drogue.

26. The refueling drogue of claim 25, wherein the air turbine is adapted to retract substantially completely inside the refueling drogue.

27. The refueling drogue of claim 21, further comprising a refueling drogue basket, wherein a maximum diameter of air turbine is less than a greatest exterior diameter of the refueling drogue basket when the refueling drogue basket is fully deployed.

28. The refueling drogue of claim 21, wherein the rotating mass is supported by the air turbine.

29. The refueling drogue of claim 20, wherein the refueling drogue further comprises an air intake adapted to direct air from the air stream into the refueling drogue, and wherein the air directed into the refueling drogue is directed past the air turbine to expose the air turbine to the air stream to rotate the rotatable mass.

30. The refueling drogue of claim 29, wherein the air turbine is a radial turbine.

31. The refueling drogue of claim 30, wherein the refueling drogue is adapted to direct the air directed into the refueling drogue into a cavity in the radial turbine and direct the air through slots extending at angles through the radial turbine to rotate the radial turbine.

32. The refueling drogue of claim 30, wherein the radial turbine is the rotating mass or part of the rotating mass.

33. The refueling drogue of claim 30, wherein the radial turbine includes slots extending radially and substantially equally spaced through the radial turbine.

34. The refueling drogue of claim 30, wherein the radial turbine has an axis of rotation that is about parallel to a longitudinal axis of the refueling drogue.

35. The refueling drogue of claim 30, wherein the radial turbine has an axis of rotation that is coaxial to a longitudinal axis of the refueling drogue.

36. The refueling drogue of claim 30, wherein the radial turbine has an axis of rotation that is not coaxial to a longitudinal axis of the refueling drogue.

37. The refueling drogue of claim 1, wherein the refueling drogue is adapted to be effectively stabilized when the mass rotates with a speed between about 1000 RPM and about 20,000 RPM.

38. The refueling drogue of claim 1, wherein the rotatable mass is about 10% to about 20% of the total mass of the refueling drogue.

39. The refueling drogue of claim 1, wherein the rotatable mass is about 40% to about 60% of the total mass of the refueling drogue.

40. The refueling drogue of claim 1, wherein the refueling drogue is adapted to generate electricity by harnessing an air stream flowing past the refueling drogue that results from a forward velocity of the refueling drogue through the atmosphere to energize or power components onboard the refueling drogue.

41. The refueling drogue of claim 20, wherein a generator is attached to the air turbine, and wherein the air turbine is adapted to rotate the rotor of the generator when exposed to the air stream to generate electricity to energize or power components onboard the refueling drogue.

42. The refueling drogue of claim 40, wherein a generator is connected to the rotating mass such that the rotation of the rotating mass rotates a portion of the generator to generate the electricity.

43. he refueling drogue of claim 1, further comprising a plurality of rotatable masses, wherein the rotatable masses are adapted to effectively stabilize the refueling drogue via a gyroscopic effect of the rotating masses on the refueling drogue when the refueling drogue is placed in an airstream.

44. The refueling drogue of claim 43, wherein respective centerlines of rotation of the plurality of rotating masses are coaxially aligned.

45. The refueling drogue of claim 43, wherein respective centerlines of rotation of the plurality of rotating masses are parallel to one another.

46. The refueling drogue of claim 43, wherein respective centerlines of rotation of the plurality of rotating masses are uniformly arrayed about the center of mass of the refueling drogue.

47. The refueling drogue of claim 1, further including aerodynamic surfaces adapted to passively stabilize the refueling drogue.

48. The refueling drogue of claim 47, wherein the aerodynamic surfaces are located on a refueling hose.

49. The refueling drogue of claim 47, wherein the aerodynamic surfaces are located on the refueling drogue.

50. A refueling drogue comprising:
a refueling drogue; and
an active control system.

51. The refueling drogue of claim 50, wherein the active control system is adapted to regulate the vertical and horizontal position of the drogue to maintain a substantially fixed orientation relative to a refueling aircraft.

52. The refueling drogue of claim 51, wherein the active control system is adapted to regulate the vertical and horizontal position of the drogue to maintain a substantially fixed orientation relative to a refueling aircraft when the refueling aircraft is flying at a substantially constant altitude, airspeed and heading.

53. The refueling drogue of claim 50, wherein the active control system comprises a plurality of control surfaces located on the refueling drogue.

54. The refueling drogue of claim 53, wherein the plurality of control surfaces are located on a refueling drogue hose connector.

55. The refueling drogue of claim 50, wherein the active control system comprises two pairs of control surfaces orthogonal to one another.

56. The refueling drogue of claim 55, wherein the active control system is adapted to actively regulate the location of the refueling drogue at substantially any rotation angle of the control surfaces from at least one of a horizontal plane and a vertical plane.

57. The refueling drogue of claim 56, further comprising a sensor adapted to measure the rotation angle γ.

58. The refueling drogue of claim 50, wherein the refueling drogue is adapted to be connected to a refueling hose, and wherein the active control system further comprises a control system adapted to regulate an angle θ and an angle ψ of an axis through the center of the refueling hose at the location where the refueling hose connects to the refueling drogue.

59. The refueling drogue of claim 58, further comprising a refueling hose connector rigidly connected to the refueling hose, wherein at least a portion of the refueling hose connector is adapted to move relative to a main body of the refueling drogue, and wherein the angle θ and the angle ψ of the axis through the center of the refueling hose is regulated by regulating angles of the refueling hose connector.

60. The refueling drogue of claim 58, wherein the control system is adapted to substantially maintain the angle θ and the angle ψ of the axis through the center of the refueling hose at respective reference angles.

61. The refueling drogue of claim 60, wherein a yaw angle of the axis of the refueling drogue is measured in a horizontal plane and is substantially zero degrees from a direction of the air stream, and wherein a pitch angle of the axis of the refueling drogue is measured in a vertical plane and is a non-zero angle from a reference plane corresponding to the horizontal plane.

62. The refueling drogue of claim 50, further comprising:

a rotatable mass; wherein

the rotatable mass is adapted to effectively stabilize the refueling drogue via a gyroscopic effect of the rotating mass on the refueling drogue when the refueling drogue is placed in an airstream.

63. The refueling drogue of claim 50, wherein the active control system comprises:

a sensor adapted to measure a varying angle between an axis through the center of the refueling hose at a location where the refueling hose is connected to the refueling drogue and a direction of the air stream.

64. The refueling drogue of claim 50, further comprising:

a first sensor adapted to measure a first varying angle between an axis through the center of the refueling hose and a direction of the air stream; and

a second sensor adapted to measure a second separate varying angle between an axis through the center of the refueling hose and the direction of the air stream; wherein

the active control system is adapted to regulate the location of the refueling drogue based on the measured first varying angle and the measured second varying angle.

65. The refueling drogue of claim 64, wherein the drogue is adapted to permit the first sensor and the second sensor to rotate relative to the horizontal plane and the vertical plane.

66. The refueling drogue of claim 64, wherein the first varying angle lies on a plane that is substantially orthogonal to a plane on which the second varying angle lies.

67. The refueling drogue of claim 64, wherein the first varying angle lies on a plane that is not substantially orthogonal to a plane on which the second varying angle lies.

68. The refueling drogue of claim 66, further comprising a pair of control surfaces orthogonal to another pair of control surfaces, wherein the plane on which the first varying angle lies is on a plane through an axis of symmetry of the refueling drogue and orthogonal to a plane on which one of the pairs of control surfaces lies.

69. The refueling drogue of claim 66, further comprising a first pair of control surfaces orthogonal to a second pair of control surfaces, wherein the plane on which the first varying angle lies is on a plane through the first pair of control surfaces and wherein the plane on which the second varying angle lies is on a plane through the second pair of control surfaces.

70. The refueling drogue of claim 64, wherein at least one of the first sensor and the second sensor includes a rotary vane adapted to pivot about a vane axis and a sensor adapted to output a signal indicative of the angle of pivot about the vane axis.

71. The refueling drogue of claim 64, wherein at least one of the first and second sensors is located substantially at a refueling hose-refueling drogue pivot point.

72. The refueling drogue of claim 50, wherein the active control system is adapted to reduce displacement of the refueling drogue to about 12 inches or less when exposed to moderate turbulence.

73. The refueling drogue of claim 51, wherein the active control system is adapted to reduce displacement of the refueling drogue to about 6 inches or less when exposed to moderate turbulence.

74. The refueling drogue of claim 50, wherein the active control system is adapted to reduce displacement of the refueling drogue to a few inches or less when exposed to moderate turbulence.

75. The refueling drogue of claim 50, wherein the refueling drogue is connected to a refueling hose, wherein the active control system is adapted to compute a pitch angle θ' and a yaw angle ψ' of an axis through the center of the refueling hose at a location where the refueling hose connects to the refueling drogue.

76. The refueling drogue of claim 75, further comprising a computer adapted to calculate at least one of a displacement and a position of the refueling drogue based on the measured pitch angle and the yaw angle of the axis through the center of the refueling hose.

77. The refueling drogue of claim 75, further comprising a computer adapted to calculate at least one of a displacement and a position of the refueling drogue based on the measured pitch angle and the yaw angle of the axis through the center of the refueling hose and a proportionality constant.

78. The refueling drogue of claim 77, wherein the displacement and the position of the refueling drogue is calculated utilizing an algorithm having a foundation in the equations:

$y = f(\theta')$, and

$z = g(\psi')$, where

y = a distance in the plane in which the angle θ lies;

z = a distance in the plane in which the angle ψ lies,

θ' = the pitch angle of the refueling hose, and

ψ' = the yaw angle of the refueling hose, and

f and g are functions that describe the relation between y and θ' and z and ψ'.

79. The refueling drogue of claim 50, further comprising an autonomous docking system.

80. The refueling drogue of claim 62, further comprising an autonomous docking system.

81. The refueling drogue of claim 79, wherein the autonomous docking system is adapted to vary the position of the refueling drogue so that a centerline of the refueling drogue remains substantially coaxial with a centerline of a refueling probe of a receiver aircraft that is not yet in contact with the refueling drogue.

82. The refueling drogue of claim 81, wherein the autonomous docking system comprises a sensor, and wherein the autonomous docking system is adapted to vary the position of the refueling drogue based on information received by the sensor indicative of the position of an end of the refueling probe of the receiver aircraft.

83. The refueling drogue of claim 81, wherein the autonomous docking system is adapted to measure an angle η and an angle λ between the refueling drogue and a point on the refueling probe of the receiver aircraft, and wherein the autonomous docking system is adapted to vary the position of the refueling drogue based on the measurements of these angles.

84. The refueling drogue of claim 83, wherein the autonomous docking system is adapted to measure a plurality of angles η and average the plurality of angles η and an a plurality of angles λ and average the plurality of angles λ between the refueling drogue and a point on the refueling probe of the receiver aircraft, and wherein the autonomous docking system is adapted to vary the position of the refueling drogue based on the averages of these angles.

85. The refueling drogue of claim 83, wherein the autonomous docking system is adapted to position the refueling drogue so that the average of the of the measured plurality of angles η and average the plurality of measured angles η are substantially reduced to zero.

86. The refueling drogue of claim 81, wherein the autonomous docking system comprises a radiation receiver, and wherein the autonomous docking system is adapted to vary the position of the refueling drogue based on received radiation indicative of the position of an end of the refueling probe of the receiver aircraft.

87. The refueling drogue of claim 86, further comprising a radiation emitter located on the refueling drogue.

88. The refueling drogue of claim 86, wherein the receiver is adapted to receive radiation emitted from a receiver aircraft.

89. The refueling drogue of claim 86, wherein the receiver is adapted to receive at least one of a microwave beam and an optical beam.

90. The refueling drogue of claim 86, wherein the receiver is adapted to receive an identification code, and wherein the autonomous docking system is configured to compare the identification code to a code in a database.

91. The refueling drogue of claim 86, wherein the receiver is adapted to sense at least one of a varying signal and a varying field, wherein the at least one of a varying signal and a varying field varies based on the location of the receiver aircraft.

92. The refueling drogue of claim 79, wherein the autonomous docking system is adapted to automatically maneuver the refueling drogue to the refueling probe of the receiver aircraft.

93. The refueling drogue of claim 79, wherein the autonomous docking system is adapted to measure an angle between the refueling drogue and the refueling probe of the receiver aircraft.

94. The refueling drogue of claim 79, wherein the autonomous docking system is adapted to measure a first angle between the refueling drogue and the refueling probe of the receiver aircraft measured on a first plane and to measure a second angle between the refueling drogue and the refueling probe of the receiver aircraft measured on a second plane.

95. The refueling drogue of claim 94, wherein the autonomous docking system is adapted to regulate the location of the refueling drogue relative to the refueling probe of the receiver aircraft so that the first and second angles are reduced.

96. The refueling drogue of claim 95, wherein the autonomous docking system is adapted to adjust the location of the refueling drogue relative to the refueling probe of the receiver aircraft so that the first and second angles are reduced to substantially zero degrees.

97. The refueling drogue of claim 96, further comprising a control circuit utilizing an error signal input to regulate the location of the refueling drogue so that the first and second angles are reduced to substantially zero degrees, wherein the circuit is adapted to convert the first and second angles to error signals.

98. The refueling drogue of claim 50, further comprising an autonomous docking system, wherein the autonomous docking system is in communication with the control system to vary the position of the refueling drogue so that a centerline of the refueling drogue remains substantially coaxial with a centerline of a refueling probe of a receiver aircraft that is not yet in contact with the refueling drogue.

99. The refueling drogue of claim 50, further comprising an autonomous docking system, wherein the autonomous docking system is in communication with the control system and adapted to maneuver the refueling drogue to a refueling probe of a receiver aircraft.

100. The refueling drogue of claim 50, wherein the active control system comprises an autonomous docking system, adapted to maneuver the refueling drogue to a refueling probe of a receiver aircraft.

101. A refueling drogue spin stabilization kit comprising:

a spin stabilization pack including a rotatable mass, wherein the spin stabilization pack is adapted to connect to at least one of a refueling hose and a refueling drogue, and wherein the spin stabilization pack is adapted such that when connected to the refueling hose or the refueling drogue, the spin stabilization pack effectively stabilizes the refueling drogue via a gyroscopic effect of the rotating mass on the refueling drogue when the refueling drogue is placed in an airstream.

102. The kit of claim 101, wherein at least a portion of the spin stabilization pack is adapted to rigidly connect to the refueling drogue such that the orientation of the

refueling drogue is substantially fixed with respect to the orientation of the spin stabilization pack.

103. The kit of claim 101, wherein the rotating mass is connected to a air turbine, and wherein the air turbine is adapted to rotate the rotatable mass when exposed to the air stream when the air stream has a relative velocity to the spin stabilization kit in excess of about 50 KEAS to produce the gyroscopic effect.

104. The kit of claim 103, wherein the air turbine is enclosed in the spin stabilization pack.

105. The refueling drogue of claim 103, wherein the air turbine is a radial turbine.

106. The refueling drogue of claim 105, wherein the spin stabilization kit is adapted to direct air from an air stream flowing past the spin stabilization pack into a cavity in the radial turbine and to direct the air through slots extending at angles through the radial turbine to rotate the radial turbine.

107. The refueling drogue of claim 105, wherein the radial turbine is the rotating mass.

108. A method of effectively stabilizing a refueling drogue, comprising:
extending a refueling drogue from an aircraft into an air stream; and
rotating a rotatable mass to create an effective gyroscopic effect on the refueling drogue to effectively stabilize the refueling drogue.

109. The method of claim 108, wherein the refueling drogue is effectively stabilized by the gyroscopic effect in an airstream having a relative velocity to the refueling drogue of more than about 80 KEAS.

110. The method of claim 108, wherein the refueling drogue is extended from a refueling hose, further comprising:

supplying aviation fuel to an aircraft through the refueling drogue.

111. The method of claim 108, wherein effective stabilization is obtained without the use of an active stabilization system.

112. The method of claim 108, wherein effective stabilization is obtained passively.

113. The method of claim 108, further comprising harnessing air from the air stream to rotate the rotatable mass to produce the effective gyroscopic effect.

114. The method of claim 113, further comprising using an air turbine to harness the air from the air stream to rotate the rotatable mass.

115. The method of claim 108, further comprising actively controlling the refueling drogue while the refueling drogue is extended in the air stream.

116. The method of claim 115, further comprising regulating the vertical and horizontal position of the drogue to maintain a substantially fixed orientation relative to a refueling aircraft.

117. The method of claim 115, further comprising regulating the vertical and horizontal position of the drogue utilizing with the active control system utilizing twp pairs of control surfaces orthogonal to one another.

118. The method of claim 115, further comprising regulating the vertical and horizontal position of the drogue utilizing with the active control system utilizing two pairs of control surfaces, the pairs being orthogonal to one another, while the refueling drogue rotates about its longitudinal axis.

119. The method of claim 115, further comprising regulating a pitch angle and a yaw angle of an axis through the center of the refueling hose at the location where the refueling hose connects to the refueling drogue.

120. The method of claim 119, wherein the yaw angle is regulated to substantially zero degrees from a direction of the air stream.

121. The method of claim 120, wherein the pitch angle is regulated to substantially constant non-zero angle from a reference plane corresponding to a horizontal plane.

122. The method of claim 115, wherein actively controlling the refueling drogue comprises:

measuring a varying angle between an axis through the center of the refueling hose at the location where the refueling hose connects to the refueling drogue and a direction of the air stream.

123. The method of claim 118, wherein actively controlling the refueling drogue comprises:

measuring a first varying angle between an axis through the center of the refueling hose at the location where the refueling hose connects to the refueling drogue and a direction of the air stream;

measuring a second varying angle between axis through the center of the refueling hose at the location where the refueling hose connects to the refueling drogue and the direction of the airstream; and

regulating the location of the refueling drogue based on the measured first varying angle and the measured second varying angle.

124. The method of claim 115, wherein actively controlling the refueling drogue comprises:

measure the pitch angle and the yaw angle of an axis through the center of the refueling hose at the location where the refueling hose connects to the refueling drogue.

125. The method of claim 124, further comprising approximating at least one of a displacement and a position of the refueling drogue based on the measured pitch angle and the measured yaw angle of the axis through the center of the refueling hose at the location where the refueling hose connects to the refueling drogue. hose.

126. The method of claim 124, wherein the displacement and the position of the refueling drogue is approximated utilizing an algorithm having a foundation in the equations:

$y = f(\theta')$, and

$z = g(\psi')$, where

y = a distance in the plane in which the angle θ' lies,

z = a distance in the plane in which the angle ψ' lies,

θ' = the pitch angle of the refueling hose, and

ψ' = the yaw angle of the refueling hose,

where

f and g are functions that describe the relation between y and θ' and z and ψ'.

127. The method of claim 115, further comprising varying the position of the refueling drogue so that a centerline of the refueling drogue remains substantially coaxial with a centerline of a refueling probe of a receiver aircraft that is not yet in contact with the refueling drogue.

128. The method of claim 127, wherein the position of the refueling drogue is varied based on received radiation indicative of the position of an end of the refueling probe of the receiver aircraft.

129. The method of claim 115, further comprising automatically maneuvering the refueling drogue to a refueling probe of a receiver aircraft.

130. The method of claim 115, further comprising measuring an angle between the refueling drogue and a refueling probe of a receiver aircraft.

131. The method of claim 115, further comprising automatically measuring a first angle between the refueling drogue and a refueling probe of a receiver aircraft measured on a first plane and measuring a second angle between the refueling drogue and the refueling probe of the receiver aircraft measured on a second plane.

132. The method of claim 131, further comprising automatically adjusting the location of the refueling drogue relative to the refueling probe of the receiver aircraft so that the first and second angles are reduced.

133. The method of claim 132, further comprising automatically adjusting the location of the refueling drogue relative to the refueling probe of the receiver aircraft so that the first and second angles are reduced to substantially zero degrees